Composite Engineer's Viewpoint

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Mechanically Fastened Joints in Composite Structures
Part 2A – Bearing Strength

In the last newsletter I stated that we would be investigating the 10 major issues that composite engineers face when joining composite structures with fasteners. The first of these issues is determining the bearing strength of the composite laminate. The bearing strength of composite structures is notably lower than that in metals. The bearing strength is also a function of the ply orientation and through-the-thickness distribution.

Bearing strength in composite materials is influenced by both the compressive strength and shear strength of the laminate configuration. We must note that there is a conflicting issue with the configuration, since increasing the 0 degree ply orientation will improve compression strength, but decrease shear strength. On the other hand, more angled ply orientations (in particular 45 degree plies) the shear strength improves, but compressive strength reduces. This trend has similar effects with the bearing strength. There is a dominance of the shear strength relationship as shown in early investigations resulting in Figure 1 (early edition of MILHBK 17), and more recently the work of John Hart-Smith, Figure 2.

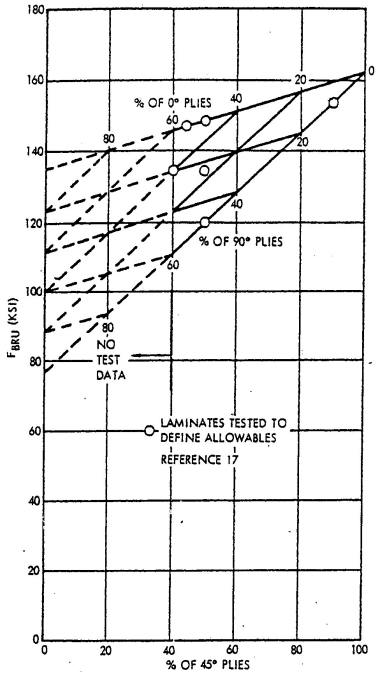


Figure 1

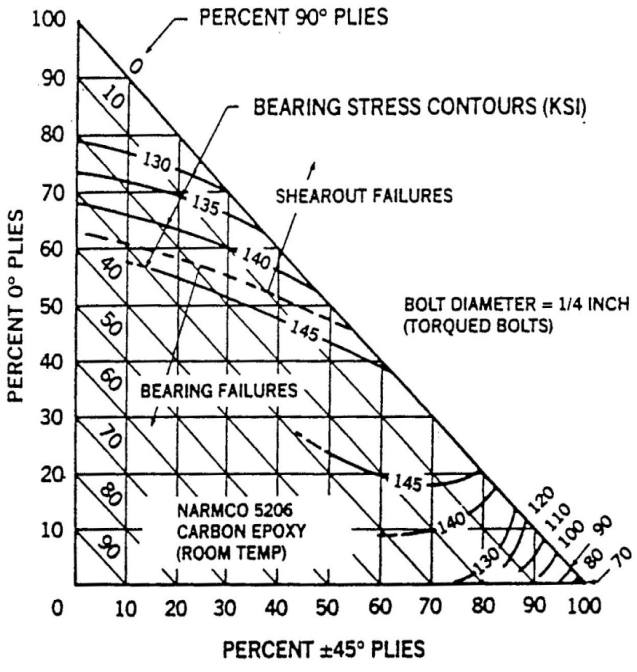
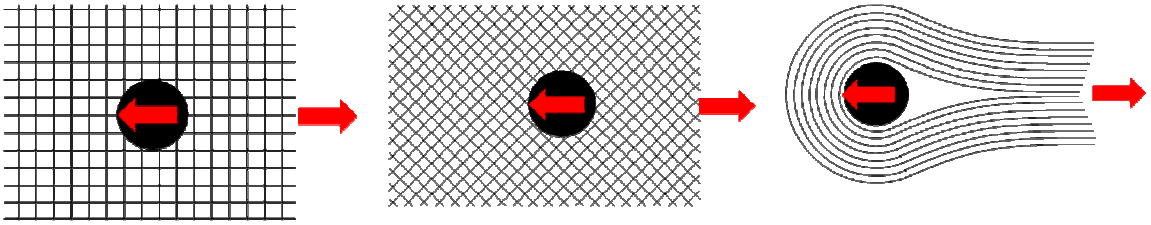


Figure 2

Thus it seems rather clear that fibre angle has a significant effect on bearing strength. Too many 0 degree fibres will have a negative impact on bearing strength and the 90 degree plies have little

impact. The angle plies, particularly the ±45 degree orientation provide the greatest beneficial influence to the bearing strength. The same effects are seen with woven cloth, with the cross-ply cloth giving reasonable bearing strength, but the angled ply cloth being significantly more superior. Further refinement with tow placement will provide the greatest bearing strength, Figure 3



Cross-Ply Cloth Angle-Ply Cloth Tow Placement

Figure 3

The comparative bearing strength properties of composite materials and conventional metals is shown in Table 1 and supported by the figure to the right (Hart-Smith). The bearing strength of composite materials is significantly less that comparable metals and thus only achieves marginal joint efficiencies. To improve this poorer bearing performance we can vary the local thickness of the composite joint region by adding extra plies (specifically more angled plies). Note well that as you increase the number of 0 degree plies the first three listed properties in Table 1 increase, but at the expense of shear and bearing strength. The reverse is true by increasing the percentage of angled (45) degree plies in the laminate.

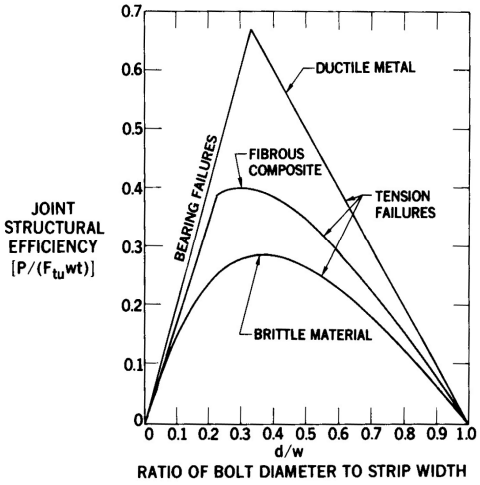


Table 1: Material Property Comparison

MATERIAL PROPERTY	ALUMINIUM 7075-T6	TITANIUM 6Al-4V	GRAPHITE/ EPOXY AS4/3501 (QI)
Elastic Modulus GPa (msi)	71.0 (10.3)	110.3 (16.0)	54.8 (7.95)
Tensile Yield Strength MPa (ksi)	448 (65)	827 (120)	First Ply Failure 317 (46)
Tensile Ultimate Strength MPa	517 (75)	896 (130)	710 (103)
Shear Strength MPa (ksi)	324 (47)	524 (76)	331 (48)
Bearing Strength MPa (ksi)	965 (140)	1,680 (244)	415 (60)

In the next article we will discuss bearing strength with a review of plate bending effects and through-the-thickness reinforcement. I also welcome questions, comments and your point of view. Feel free to contact me via r.heslehurst@adfa.edu.au. I may publish your questions and comments, and my response in future newsletters.
